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### Scope of the Claims

1. Magnetic tape—in [the context of] magnetic tape in which a magnetic layer is formed on a surface of a base—characterized in that:  
a layer comprising a pigment is formed on the surface opposite the surface on which the magnetic layer is provided on the base, and the layer [comprising the pigment] is made to be a layer on which servo signals for tracking can be optically recorded.
2. The magnetic tape according to claim 1, wherein the layer comprising the pigment is illuminated with light of a specified wavelength from the side with the layer [comprising the pigment] in the magnetic tape to discolor the pigment and form a discoloration pattern of a specified shape in which servo signals are recorded.
3. The magnetic tape according to claim 1 or 2, wherein the dynamic coefficient of friction of the side with the layer comprising the pigment in the magnetic tape is 0.15 to 0.35.
4. The magnetic tape according to any of claims 1 to 3, wherein the layer comprising the pigment is an outermost layer and further comprises a binder.
5. The magnetic tape according to any of claims 1 to 3, wherein a backcoating layer as an outermost layer comprising a binder and an inorganic powder is further formed on the layer comprising the pigment.
6. The magnetic tape according to claim 4 or 5, wherein the layer comprising the pigment or the backcoating layer comprises as the inorganic powder<sup>4</sup> electrically conducting inorganic microparticles with a mean primary particle diameter of 1 to 100 at 10 to 800 parts by weight per 100 parts by weight of the binder.
7. The magnetic tape according to claim 6, wherein the electrically conducting inorganic microparticles comprise tin oxide, antimony-doped tin oxide, indium-doped tin oxide, or indium oxide.
8. The magnetic tape according to any of claims 2 to 7, wherein the discoloration pattern comprises a single or plurality of continuous lines of a specified width along the lengthwise direction of the [magnetic] tape.

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<sup>4</sup> The term "inorganic powder" is mentioned only in claim 5 even though this claim depends from both claims 4 and 5. The original specifically states "the" (as opposed to "an") inorganic powder.

9. The magnetic tape according to any of claims 2 to 7, wherein the discoloration pattern comprises a discontinuous line of a specified width along the lengthwise direction of the [magnetic] tape.
10. The magnetic tape according to any of claims 1 to 9, wherein at least one magnetic or nonmagnetic intermediate layer is provided between the base and the magnetic layer, and acicular or spindle-shaped ferromagnetic powder with a major axis length of 0.03 to 0.2  $\mu\text{m}$  or tabular ferromagnetic hexagonal ferrite powder with a tabular diameter of 0.01 to 0.08  $\mu\text{m}$  is included in the magnetic layer.
11. The magnetic tape according to any of claims 1 to 10, wherein light of a specified wavelength is illuminated on the discoloration pattern from one side of the magnetic tape, and light passing through to the other side is detected to allow detection of the servo signals indicated by the intensity of the detected light.
12. The magnetic tape according to any of claims 1 to 11, wherein the electrical surface resistivity on the side with the layer comprising the pigment in the magnetic tape is  $1 \times 10^9 \Omega$ /[missing unit] or less.
13. The magnetic tape according to any of claims 1 to 12, wherein the transmittance of light of the magnetic tape at a wavelength of light used in the reading of the servo signals is at least 3% [of the value] prior to servo signal recording.
14. The magnetic tape according to any of claims 1 to 10, wherein a thin metal layer<sup>5</sup> is further formed between the base and the layer comprising the pigment, light of a specified wavelength is illuminated on the discoloration pattern from the side with the layer comprising the pigment of the magnetic tape, and light reflecting back is detected to allow detection of the servo signals indicated by the intensity of the detected light.
15. The magnetic tape according to claim 14, wherein the reflectivity on the side with the layer comprising the pigment of the magnetic tape at a wavelength of light used in the reading of the servo signals is at least 5% [of the value] prior to servo signal recording.
16. The magnetic tape according to claim 14 or 15, wherein a second thin metal layer is further formed between the base and the magnetic layer.
17. Magnetic tape—in [the context of] magnetic tape in which a magnetic layer is formed on a surface of a base—characterized in that:  
a layer comprising a pigment is formed on the surface opposite the surface on which the magnetic layer is provided in the base, and servo signals for tracking are optically recorded on the layer [comprising the pigment].

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<sup>5</sup> Literally, "metal thin-film layer."

## Detailed Description of the Invention

[0001]

### *Technical Field of the Invention*

The invention relates to magnetic tape capable of optically recording servo signals for tracking and, more specifically, relates to magnetic tape capable of optically recording servo signals for tracking on the surface opposite a magnetic recording surface.

[0002]

### *Prior Art and Problems the Invention is to Solve*

In recent years, the expanding scale of personal computer networks, the importance of the security aspect of data management, and other matters have raised the demand for larger storage capacities for magnetic tape as a medium for data backup. Means for increasing capacity are methods to improve recording density and methods to extend the tape length.

[0003]

With regard to methods for extending the tape length, the length of wound tape that can be housed in a tape cartridge is the upper limit of the recording capacity, so the tape thickness must be reduced in order to bring about greater capacity. Therefore, greater capacities have limits when such methods alone are relied on. With respect to the methods for increasing recording density, it is known that the recording density of magnetic tape is lower than the recording density of a hard disk drive, and serpentine type magnetic tape in particular has a low recording density. The reason for the low recording density of serpentine type magnetic tape is the low track density. On the other hand, helical scan type magnetic tape, another recording mode, is known for having a higher track density than serpentine type magnetic tape. This is because a servo tracking system called automatic track finding (ATF) is used in helical scan type magnetic tape.

[0004]

A servo tracking system has been adopted in serpentine type magnetic tape as well as a means for improving the track density. As such a servo tracking method, a method in which servo signals are written on the same track as the data track on the magnetic recording surface (an embedded servo system) and a method in which a dedicated servo track is provided on the magnetic recording surface have been proposed. In Japanese Patent Publication No. H7-82626, a tracking system is proposed as a servo tracking system for instances in which the pitch of data tracks is several tens of microns, in which a dedicated servo track is provided on the magnetic recording surface and servo signals for tracking are read with a plurality of servo signal reproduction heads. According to this method, however, the number of servo signal reproduction heads must be increased as the number of tracks increases, and in order to avoid this, the [number of] servo tracks must be increased. In this manner, conventional servo tracking systems use the same area as the data area of the magnetic recording surface as the area for servo tracking, which problematically results in the reduction of the area of the data area. This problem is particularly conspicuous in the servo tracking system of Japanese Patent Publication No. H7-82626, in which there is a high track density at about 30 tpmm (tracks per mm) or greater.

[0005]

Accordingly, an object of the invention is to provide magnetic tape that can perform servo tracking without reducing the area of the data area.

Another object of the invention is to provide magnetic tape with a greater track density.

Still another object of the invention is to provide magnetic tape having a high recording capacity.

[0006]

***Means for Solving the Problems***

As a result of extensive investigation, the inventors found that magnetic tape capable of achieving the above objects could be obtained by forming a layer capable of optically recording servo signals for tracking of a surface opposite a magnetic recording surface on the magnetic tape.

[0007]

Completed based on the above finding, the invention has accomplished the above objects by providing magnetic tape—in [the context of] magnetic tape in which a magnetic layer is formed on a surface of a base—characterized in that a layer comprising a pigment is formed on the surface opposite the surface on which the magnetic layer is provided in the base, and the layer is made capable of optically recording servo signals for tracking.

[0008]

In addition, the invention provides magnetic tape—in [the context of] magnetic tape in which a magnetic layer is formed on a surface of a base—characterized in that a layer comprising a pigment is formed on the surface opposite the surface on which the magnetic layer is provided in the base, and on the layer is optically recorded servo signals for tracking.

[0009]

***Embodiments of the Invention***

Hereafter, the magnetic tape of the invention will be described with reference to the drawings based on the preferred embodiments thereof. Herein, Fig. 1 is a summary view showing the structure of the first preferred embodiment of the magnetic tape of the invention, Fig. 2 is a schematic view illustrating a method for illuminating a light beam on the pigment-comprising layer to form a discoloration pattern, and Fig. 3 is an expanded plan view of the essential parts of the pigment-comprising layer following light-beam illumination.

[0010]

In the magnetic tape 1 of the preferred embodiment shown in Fig. 1, an intermediate layer 3 is provided on a base 2, and a magnetic layer 4 is provided as a topmost layer adjoining the intermediate layer 3. In addition, a layer 5 comprising a pigment (hereinafter referred to as "pigment-comprising layer") is provided on the other surface of the base 2.

[0011]

Magnetic tape 1 shown in Fig. 1 employs a serpentine recording method, and the magnetic layer 4 is made such that a plurality of data tracks are formed in parallel to the running direction of the magnetic tape 1. When the magnetic tape 1 is in use, a head unit comprising a specified number of magnetic heads is moved successively widthwise on the magnetic tape 1, switching among data tracks and recording and reproducing data for the data track corresponding to each magnetic head. Moreover, servo tracking is carried out so that each magnetic head may be positioned on an appropriate data track when switching among the tracks or during recording or reproduction.



[0012]

The pigment-comprising layer 5 constitutes the outermost layer of the magnetic layer 4 and the magnetic tape 1. A pigment 5 that discolors under the illumination of light of a specified wavelength and whose light absorption at a specified wavelength is included in the pigment-comprising layer 5. The wavelengths of these two types of light may be the same or different. In this Specification, "light" is not limited to visible light and also means light of wavebands other than that [of visible light]. Therefore, "pigment" in this Specification means not only a substance that emits light in the waveband of visible light, that is, a substance that absorbs light in the visible waveband, but also substances that absorb light in other wavebands.

[0013]

With regard to the pigment-comprising layer 5, a discoloration pattern of a specified shape on which servo signals are recorded is formed on the pigment-comprising layer 5 through the discoloration of the pigment by illuminating light of a specified wavelength from the side with the pigment-comprising layer 5 in the magnetic tape 1. A method for forming the discoloration pattern will be discussed with reference to Fig. 2.

[0014]

As shown in Fig. 2, laser beams 41, 41, ...are illuminated parallel to each other toward the pigment-comprising layer 5 of the magnetic tape 1, which runs at a specified speed in the direction of Arrow A in the figure, from a plurality of laser light sources 40, 40,... arranged at a specified interval along the widthwise direction of the magnetic tape 1. The pigment present at the portions that the laser beam 41 illuminates at the pigment-comprising layer 5 are degraded in a reaction under the energy of the laser and discolor. When this is to be done, the illumination conditions of the laser beam 41 are adjusted so that discoloration of the pigment of the pigment-comprising layer 5 takes place at the portion that the laser beam 41 has illuminated. This discoloration causes a discoloration pattern 10 of a specified shape to form on the pigment-comprising layer 5. The discoloration should be of an extent that allows the presence or absence of discoloration to be detected by measuring the intensity of transmitted light, reflected light, or phosphorescent light. The discoloration pattern in this embodiment, as Fig. 2 shows, is a pattern comprising a plurality of continuous lines having a specified width along the lengthwise direction of the magnetic tape 1. The width  $w$  of the discoloration pattern 10 and the degree of discoloration through the thickness of the pigment-comprising layer 5 can be regulated by adjusting the beam diameter and output of the laser beam 41. In this embodiment, the beam diameter preferably ranges from 0.25 to 30  $\mu\text{m}$  and particularly 1 to 25  $\mu\text{m}$ , and the output is preferably 1 to 1000 mW and particularly 10 to 100 mW. The wavelength of the laser beam is appropriately selected according to the type [of the pigment] so that the pigment used is adequately discolored. Note that in Fig. 2, the discoloration pattern 10 is drawn in an emphasized manner. The formation of the discoloration pattern 10 may be performed with a dedicated device before the use of the magnetic tape 1 or applied to the magnetic tape 1 in a recording and playback drive in which the device shown in Fig. 2 is installed.

[0015]

The details of the discoloration pattern formed as discussed above will be explained with reference to Fig. 3. The discoloration patterns 10, 10, ... are straight lines each having a predetermined width that are formed with equal spacing across the widthwise direction of the magnetic tape 1 and parallel to the lengthwise direction of the magnetic tape 1. In addition, the discoloration patterns 10 are normally formed across the entire length of the region of the pigment-comprising layer 5, which corresponds to the region in which the magnetic layer 4 is formed, in the lengthwise direction of the magnetic tape 1. The region in which the discoloration patterns are formed, however, is not limited thereto. The discoloration patterns 10 are made to be capable of producing optical contrast relative to the portion that is not discolored in the pigment-comprising layer 5. As noted above, the data tracks in the magnetic layer 4 are also formed in parallel along the lengthwise direction of the magnetic tape 1 as are the discoloration patterns 10, but there are no particular limits as to the relative spatial relationship between the data tracks and the discoloration patterns 10.

[0016]

Specific examples of the optical contrast produced by the discoloration patterns 10 are contrast generated by illuminating light of a specific wavelength at the discoloration patterns 10 and using the gradations in the intensity of the transmitted light and contrast generated by illuminating light of a specific wavelength at the discoloration patterns 10 and using the gradations in the intensity of the reflected light.

[0017]

When contrast due to gradations in transmitted light intensity is used to perform servo tracking, the intensity of transmitted light may be detected and an optical servo system, such as a push-pull method or a three-beam method, is used to execute servo tracking. The procedure is similar when contrast due to gradations in reflected light intensity is used to perform servo tracking, in which case the intensity of reflected light may be detected and the optical servo system used to execute servo tracking. Optical servo systems such as a push-pull method or three-beam method are techniques generally used for servo tracking in various optical disks.

[0018]

Servo tracking in which transmitted light intensity is detected with a push-pull method will be discussed with reference to Fig. 4. As shown in Fig. 4(a), light from a light source 30, such as a semiconductor laser, which is situated in opposition to the pigment-comprising layer 5 of a magnetic tape running perpendicular to the surface of the paper, is condensed by a lens 31 to a specific beam diameter and then enters the discoloration pattern 10 formed on the pigment-comprising layer 5. At this time, the beam diameter is slightly smaller than the width of the discoloration pattern 10. The light passing through the discoloration pattern 10, the base 2 (not shown), the intermediate layer 3 (not shown), and the magnetic layer 4 (not shown), or in other words, the transmitted light, is detected by a light detector 33. The detected transmitted light corresponds to the servo signals recorded on the discoloration pattern 10—it is converted to an electrical signal in the light detector 33 and sent to a servo tracking processor 34. At the servo tracking processor 34, processing is performed with regard to the symmetry of the transmitted light beam intensity. In greater detail, if the beam intensity has left-right symmetry with respect to the centerline of the beam, the beam 35 is deemed to have entered the centerline of the discoloration pattern 10 as shown in Fig. 4(b). This state is an on-track state in which the magnetic head is properly positioned on a specified data track of the magnetic layer 4. If the beam intensity, however, is asymmetrical either to the left or the right with regard to the centerline of the beam, the beam 35 is deemed to have deviated from the centerline to either the left or right of the discoloration pattern 10 as shown in Figs. 4(c) and (d). This state is an off-track state in which the magnetic head is not properly positioned on the specified data track of the magnetic layer. In this case, the servo tracking processor 34 issues an order to a driving device 35 of the magnetic head 36 to move the magnetic head 36 to a proper position as shown in Fig. 4(a) and, as a result, the magnetic head 36 is properly positioned by the driving device 35, or in other words, an on-track state is returned to. An appropriate value for the wavelength of the light source used at the time of servo tracking is selected in accordance with pigment color before and after discoloration.

[0019]

As Fig. 3 shows, the width  $w$  of the discoloration pattern 10 varies according to the width of the magnetic tape 1 as well as other factors but is preferably from 0.25 to 50  $\mu\text{m}$ . When the width  $w$  is less than 0.25  $\mu\text{m}$ , current optical technology is unable to adequately condense the beam diameter, so malfunctions can occur when optically detecting the discoloration pattern. When the width  $w$  is greater than 50  $\mu\text{m}$ , on the other hand, the formation density of the discoloration pattern 10 decreases and is not preferable if the discoloration pattern 10 is formed at multiple locations as shown in Fig. 3. An even more preferable range of the width  $w$  of the discoloration pattern 10 is 0.25 to 30  $\mu\text{m}$ , and specifically 0.8 to 25  $\mu\text{m}$ .

[0020]

The pitch  $p$  between neighboring discoloration patterns 10, 10 (Fig. 3) depends on the number of discoloration patterns 10 among other factors, but it is preferably equal to or greater than the width of the data tracks formed in the magnetic layer 4 and an integer factor of the width of the tracks.

[0021]

When transmitted light is to be used for reading servo signals, the light transmittance of the magnetic tape 10 [sic] at a wavelength used to read the servo signals is preferably at least 3% and more preferably at least 5% of the value prior to discoloration, that is, prior to servo signal recording. There is no particular upper limit for light transmittance, which is preferably as high as possible, but for reasons associated with the transmittance of the magnetic layer 4, the practical upper limit is around 40%.

[0022]

The discoloration pattern 10, as shown in Fig. 3, may be present on the specified interval along the entire width of the magnetic tape 1, may be present in plurality on only a portion of the width of the magnetic tape 10 [sic], such as a specified interval at the center portion of the widthwise direction, or may be present in plurality on a specified interval on either the left or the right side. Moreover, it may also be present on specified intervals at two or more locations on the widthwise direction of the magnetic tape 10 [sic]. For example, one or more of the patterns, which may consist of the same or different number of the patterns, may be present on the left and right sides of the magnetic tape 10 [sic], one or more of the patterns, which may consist of the same or different number of the patterns, can be arranged on the central portion and one of the left or the right side portion of the tape, or one or more of the patterns, which may consist of the same or different number of patterns, can be arranged on the central portion and the left and the right side portions of the tape. And in any case, the total number of the discoloration patterns 10 is preferably the reciprocal of the integer number of the data tracks on the magnetic layer 4.

[0023]

There are no particular limits to the type of pigment provided it is a substance that discolors under the illumination of light of a specified wavelength and whose light absorbance changes at a specified wavelength. Specifically, an organic pigment such as a cyanine-type pigment, squarylium-type pigment, croconium-type pigment, azlenium-type pigment, triarylamine-type pigment, anthraquinone-type pigment, metal-containing azo-type pigment, dithiol metal complex-type pigment, indoanaline metal complex-type pigment, phthalocyanine-type pigment, naphthalocyanine-type pigment, or porphyrin-type pigment or an intermolecular-charge-transfer-complex-type pigment is preferably used. The pigments can be used either individually or as a mixture of two or more.

[0024]

The pigment-comprising layer 5 can be formed with only the above pigments, but the pigment-comprising layer 5 preferably further includes a binder from the standpoint of using the pigment-comprising layer 5 also as a backcoating layer and improving the running characteristics and durability of the magnetic tape 10 [sic]. In this case [in which the binder is added], the weight ratio of the pigment and the binder (former: latter), although varying depending on the type and other features of the pigment used, is preferably 0.01:100 to 10:100 and more preferably 0.05:100 to 5:100.

[0025]

Any substance can be used as the binder without limit provided it is usable in magnetic tape. Examples are thermoplastic resins, thermosetting resins, reactive resins, and mixtures thereof. Specifically, vinyl chloride copolymers or modifications thereof, copolymers comprising acrylic acid, methacrylic acid, or esters thereof, polyvinyl alcohol copolymers, acrylonitrile copolymers (rubber-like resins), polyester resins, polyurethane resins, epoxy resins, cellulosic resins (e.g., nitrocellulose, cellulose acetate, cellulose acetate butylate, cellulose acetate propionate), and polyamide resins can be used. The number average molecular weight of the binder is preferably 2,000 to 200,000. In order to improve the dispersing properties of various powders that can be included in the pigment-comprising layer 5 (the details of these powders will be discussed later), the binder can include a polarizing functional group (so-called polar group) such as a hydroxyl group, a carboxyl group or a salt thereof, a sulfo group or a salt thereof, a phosphate group or a salt thereof, a nitro group, a nitric ester group, an acetyl group, a sulfuric ester group or a salt thereof, an epoxy group, a nitrile group, a carbonyl group, an amino group, an alkylamino group, an alkylammonium salt group, a sulfobetaine structure, a carbobetaine structure, or another betaine structure.

[0026]

The pigment-comprising layer 5, from the standpoint of increasing the stability of the pigment, preferably contains an antioxidant. In the case [that an antioxidant is included], it is preferably added at 0.5 to 20 parts by weight and particularly 3 to 10 parts by weight per 100 parts by weight of the pigment in order to secure an adequate stability for the pigment. Specific examples of the antioxidant are bis(4-tert-butyl-1,2-dithiophenolate)copper-tetra-n-butylammonium and bis(4-tert-butyl-1,2-dithiophenolate)nickel-tetra-n-butylammonium, and any can be used with no particular limitations provided it is an antioxidant for organic pigments.

[0027]

The pigment-comprising layer 5 of the magnetic tape 1 is also used for the formation of a discoloration pattern used for the recording of servo signals employed in servo tracking as described above and preferably has functions traditionally associated with a backcoating layer in addition to this function. Examples of such functions are (1) the provision of satisfactory running characteristics to the magnetic tape, (2) the provision of electrostatic prevention for the magnetic tape, and (3) the detection of the beginning of the tape (BOT) and the end of the tape (EOT).

[0028]

To bring about function (1) above, the pigment-comprising layer 5 preferably has an appropriate surface roughness. On the other hand, the pigment-comprising layer 5 is preferably as smooth as possible so that the surface shape of the pigment-comprising layer 5 is not transferred to the magnetic layer during tape winding. In consideration of the balance between these two, the arithmetic mean roughness Ra of the pigment-comprising layer 5 is preferably from 7 to 50 nm and particularly from 8 to 30 nm, and the 10 point mean roughness Rz is preferably 40 to 250 nm and particularly 50 to 200 nm.

[0029]

The arithmetic mean roughness Ra is computed with a sensing pin surface roughness meter—it was measured under the following conditions in accordance with JIS-B0601-1994. Ra is defined with Equation (i) below.

- Needle diameter: 1.5–2.5 μm; curvature: 60°
- Needle pressure: 50–300 μN
- Cutoff: 80 μm
- Standard length: 80 μm
- Measured length: 400 μm

[0030]

[Equation 1]

$$Ra = \frac{1}{l} \int_0^l |Y(x)| dx \quad (i)$$

where Y indicates profile data and l indicates the measured length.

[0031]

The specimen to be measured is placed on a microscope slide with properties that fulfill JIS-R-3502 (in this Specification, a slide made by Matsunami Glass was used, but the slide is not limited thereto), attached with water or ethanol, and measured. At this time, an excess of water or ethanol will prevent results of good reproducibility, so the measurement taken after a certain amount of water or ethanol has evaporated and during the time interference fringe is seen from beneath the slide is taken as Ra.

[0032]

The 10 point mean roughness Rz was determined with Equation (ii) in accordance with JIS-B0601-1994 under conditions similar to those for Ra. The sample was the same as that associated with Ra above—its standard length l was 80 μm and the assessment [measurement] length l<sub>0</sub> was 400 μm.

[0033]

[Equation 2]

$$R_z = \frac{|Y_{p1} + Y_{p2} + Y_{p3} + Y_{p4} + Y_{p5}| + |Y_{v1} + Y_{v2} + Y_{v3} + Y_{v4} + Y_{v5}|}{5} \quad (ii)$$

where  $Y_{p1}$ ,  $Y_{p2}$ ,  $Y_{p3}$ ,  $Y_{p4}$ , and  $Y_{p5}$  represent the standard height of the first to the fifth highest peaks in the cutout portion corresponding to the standard length  $l$ , and  $Y_{v1}$ ,  $Y_{v2}$ ,  $Y_{v3}$ ,  $Y_{v4}$ , and  $Y_{v5}$  represent the standard height of the first to the fifth lowest valleys in the cutout portion corresponding to the standard length  $l$ .

[0034]

So that the arithmetic mean roughness  $R_a$  and the 10 point mean roughness  $R_z$  of the pigment-comprising layer 5 are within the above preferable range, an inorganic powder with a mean particle diameter of 1 to 700 nm is preferably included in the pigment-comprising layer 5. It is particularly preferable to add two or more types of inorganic powder that include an inorganic powder with a mean particle diameter of 1 to 100 nm (called "powder A") and an inorganic powder with a mean particle diameter of 50 to 700 nm (called "powder B"). The ratio (by weight) in which powder A and powder B are added is preferably 100:0.1 to 100:20 and [more] preferably 100:0.2 to 100:15. There are no particular limits to the types of powder A and powder B provided their mean particle diameters satisfy the above ranges, and a specific example is spherical particles comprising  $TiO$ ,  $TiO_2$ ,  $\alpha-Fe_2O_3$ ,  $BaCO_3$ ,  $BaSO_4$ ,  $Fe_3O_4$ ,  $\alpha-Al_2O_3$ ,  $\gamma-Al_2O_3$ ,  $CaCO_3$ ,  $Cr_2O_3$ ,  $ZnO$ ,  $ZnSO_4$ ,  $\alpha-FeOOH$ , Mn-Zn ferrite, Ni-Zn ferrite,  $ZnS$ , tin oxide, antimony-doped tin oxide (ATO), indium-doped tin oxide (ITO), indium oxide, carbon black, graphite carbon,  $SiO_2$ , or a silicone resin of a web-like construction in which siloxane bonds extend in three dimensions and a methyl group is bonded to Si. In the case [of such a powder], the types of powder A and powder B may be the same or different.

[0035]

Among the inorganic powders, carbon black and other black powders have strong light-blocking properties. Therefore, when transmitted light is to be used for reading servo signals, the inclusion of a large amount of such a black powder in the pigment-comprising layer 5 could increase light shielding and prevent an adequate amount of light from passing through. As such, a non-black powder with a particle diameter smaller than the thickness of the pigment-comprising layer 5 is preferably included in the pigment-comprising layer 5 as the powder B instead of or together with the black powder to bring about function (1) above. The preferable range of the mean particle diameter of the powder B is, as was stated above, 50 to 700 nm and particularly 50 to 500 nm. The powder B is preferably included at 0.5 to 150 parts by weight, particularly 1 to 80 parts by weight, and more particularly 2 to 40 parts by weight per 100 parts by weight of the binder.



[0036]

In order to bring about function (2) above, it is preferable to add an electrically conducting substance to the pigment-comprising layer 5. Carbon black and other black powders are representative examples of such substances. But as was stated, black powders have strong light-blocking properties, so when transmitted light is to be used for reading servo signals, the inclusion of a large amount of black powder in the pigment-comprising layer 5 could increase light shielding and prevent an adequate amount of light from passing through. As such, electrically conducting inorganic microparticles as the powder A are preferably included in the pigment-comprising layer 5 instead of or together with black powder to bring about function (2) above. In order to bring about function (2) above, the electrical surface resistivity on with side with the pigment-comprising layer 5 in the magnetic tape 10 [sic] is preferably made  $1 \times 10^9 \Omega$ /[missing unit] or less. There is no particular limit on the lower limit of electrical surface resistivity, which is preferably as low as possible.

[0037]

Examples of such electrically conducting inorganic microparticles are [those comprising] electrically conducting tin oxide, antimony-doped tin oxide (ATO), indium-doped tin oxide (ITO), or indium oxide. Such electrically conducting inorganic microparticles have a high light transmittance, a point that makes their use advantageous when transmitted light is used to read servo signals. Particularly preferable electrically conducting inorganic microparticles are [those comprising] tin oxide, antimony-doped tin oxide (ATO), indium-doped tin oxide (ITO), or indium oxide. The mean particle diameter of the electrically conducting inorganic microparticles used as powder A is preferably 1 to 100 nm, particularly 2 to 100 nm, and especially 5 to 50 nm. The electrically conducting inorganic microparticles used as powder A are preferably included at 10 to 800 parts by weight, particularly 30 to 700 parts by weight, and especially 50 to 700 parts by weight to 100 parts by weight of the above binder.

[0038]

A total number of parts of powder A and powder B added of 50 to 800 parts by weight and particularly 100 to 700 parts by weight per 100 parts by weight of the binder is preferable from the standpoints of attaining an arithmetic mean roughness Ra and a 10 point mean roughness Rz within the above-mentioned preferable range and adequately bringing about function (2).

[0039]

With regard to function (3), the function can be substituted with the discoloration pattern 10 in the magnetic tape of the invention. Conventionally, a light-transmitting method was used in the detection of EOT and BOT, so carbon black had to be included in the backcoating layer, but as a result of the above, the inclusion of carbon black for the detection of EOT and BOT in the pigment-comprising layer 5, which doubles as the backcoating layer, is unnecessary in the invention. This is very advantageous when transmitted light is used for reading servo signals as discussed above.

[0040]

A lubricant and a hardener may also be included in the pigment-comprising layer 5 in addition to the above components.

[0041]

The lubricants that can be generally used include fatty acids and fatty acid esters.

Examples of the fatty acids are caproic acid, caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, isostearic acid, linolenic acid, oleic acid, elaidic acid, behenic acid, malonic acid, succinic acid, maleic acid, glutaric acid, adipic acid, pimelic acid, azelaic acid, sebacic acid, 1,12-dodecanedicarboxylic acid, and octanedicarboxylic acid.

Examples of the fatty acid esters are alkyl esters of the above fatty acids, with those having a total number of carbon atoms from 16 to 46 carbon atoms being preferable.

An inorganic ester salt such as a phosphate ester, a fluoride compound, or a silicon compound can also be used.

These lubricants are preferably added in an amount of 0.05 to 15 parts by weight and particularly 0.2 to 10 parts by weight per 100 parts by weight of the binder.

[0042]

The hardeners that are generally used include isocyanate hardeners, exemplified by Coronate L (a product name) produced by Nippon Polyurethane Industry Co., Ltd. and amine hardeners. The hardener is added in an amount of 5 to 40 parts by weight and preferably 5 to 30 parts by weight per 100 parts by weight of the binder.

[0043]

A stabilizer or sensitizer of the above pigment can be added as necessary to the pigment-comprising layer 5.

[0044]

The pigment-comprising layer 5 is formed by applying to the base 2a pigment-comprising coating composition having the above components dispersed in a solvent. Examples of the solvent are ketone solvents, ester solvents, ether solvents, aromatic hydrocarbon solvents, and chlorinated hydrocarbon solvents as well as a cellosolve or similar solvent. The solvent is preferably added so that the solid component of the pigment-comprising coating composition constitutes 10 to 50% by weight and particularly 20 to 40% by weight.

[0045]

The thickness of the pigment-comprising layer 5, which is formed by applying the above pigment-comprising coating composition, is preferably 0.1 to 2.0  $\mu\text{m}$  and particularly 0.2 to 1.5  $\mu\text{m}$  in consideration of the balance between the transparency of the discoloration pattern 10 and the thickness of the magnetic layer 4 and intermediate layer 3.

[0046]

The plurality of the discoloration patterns 10, 10, ... along the lengthwise direction of the magnetic tape 1 is formed, as shown in Fig. 3, in the pigment-comprising layer 5 in the magnetic tape 1 of this embodiment, but instead of such discoloration patterns, a single, straight-line, continuous discoloration pattern along the lengthwise direction of the magnetic tape 1 could be formed on the pigment-comprising layer 5. Alternatively, a single or plurality of sine-wave-shaped, continuous discoloration patterns along the lengthwise direction of the magnetic tape 1 could also be formed in the pigment-comprising layer 5. And as shown in Fig. 5, a discontinuous discoloration pattern 10 along the lengthwise direction of the magnetic tape 1 could also be formed in the pigment-comprising layer 5.

[0047]

To provide an explanation of the discoloration pattern 10, shown in Fig. 5, the discoloration pattern 10 comprises a discoloration pattern 10a slanted at angle  $\theta^\circ$  relative to the lengthwise direction of the magnetic tape 1 and a discoloration pattern 10b slanted at angle  $-\theta^\circ$  that are perpendicular along the lengthwise direction of the magnetic tape 1 and symmetrical relative to the centerline c along the lengthwise direction of the magnetic tape. The value of angle  $\theta$  is influenced by the accuracy of positioning in servo tracking, so in order to secure an adequate accuracy, the value of angle  $\theta$  is preferably  $5$  to  $85^\circ$  and particularly  $10$  to  $30^\circ$ . The lengths of the discoloration pattern 10a and the discoloration pattern 10b can be different, but they are preferably the same, and are preferably each  $5$  to  $140$  mm and particularly  $5$  to  $80$  mm. The gap g between the discoloration pattern 10a and the discoloration pattern 10b with regard to the lengthwise direction of the magnetic tape 1 should be as small as possible. And even if the discoloration pattern 10 shown in Fig. 5 is used, the reading of servo signals can be performed similarly to that when the discoloration pattern 10 shown in Fig. 3 is used.

[0048]

Next, the second to fourth embodiments of the magnetic tape of the invention will be discussed with reference to Figs. 6 to 9. Herein, Fig. 6 is a summary view showing the construction of the second embodiment of the magnetic tape of the invention and corresponds to Fig. 1 of the first embodiment, Fig. 7 is a summary view showing the construction of the third embodiment of the magnetic tape of the invention and likewise corresponds to Fig. 1 of the first embodiment, Fig. 8 is a schematic view showing a method of servo tracking in the third embodiment and corresponds to Fig. 4 of the first embodiment, and Fig. 9 is a summary view showing the construction of the fourth embodiment of the magnetic tape of the invention and corresponds to Fig. 7 of the third embodiment. Note that points differing from those of the first embodiment alone will be raised in the discussion of the second through fourth embodiments, with like points not discussed, and the details regarding the first embodiment are applicable as appropriate. In Figs. 6 to 9, the reference symbols that indicate identical parts in Figs. 1 to 5 are identical.

[0049]

In the magnetic tape 1 of the second embodiment shown in Fig. 6, a discoloration pattern in which servo signals are recorded is formed in a pigment-comprising layer 5 in advance of the use of the magnetic tape similarly to the magnetic tape of the first embodiment, and at the time of use of the magnetic tape, light of a specified wavelength is illuminated from one side of the magnetic tape 1 at the discoloration pattern and the light passing through to the other side is detected to allow the reading of the servo signals expressed as the intensity of the detected light. With regard to the points of the magnetic tape 1 of this embodiment that differ from those of the magnetic tape of the first embodiment, the pigment-comprising layer in the magnetic tape in the first embodiment doubles as a backcoating layer, while in the magnetic tape 1 of the second embodiment, a backcoating layer 6 as the outermost layer independent from the pigment-comprising layer 5 is formed adjoining the pigment-comprising layer 5. Therefore, in the magnetic tape 1 in this embodiment, the function of recording and reading servo signals is entrusted to the pigment-comprising layer 5, and the function traditionally associated with a backcoating layer is entrusted to the backcoating layer 6 to allow division of functions, thus providing a greater degree of design freedom to the magnetic tape 1 than was the case with the first embodiment.

[0050]

The pigment-comprising layer 5 in this embodiment preferably is composed with the pigment alone or is composed by including another component in addition to the pigment.

[0051]

If the pigment-comprising layer 5 is composed with the pigment alone, the pigment-comprising layer 5 can be formed, for example, with methods (1) to (3) below.

- (1) A thin-film formation method such as chemical vapor deposition (CVD) or physical vapor deposition (PVD).
- (2) A method by which a coating composition, in which a pigment is dissolved in a solvent and a surfactant is added as necessary, is applied to the base 2.
- (3) A method by which a mixture in which a pigment dissolved in a polymeric resin, polymer emulsion, or other such substance is co-extruded during molten extrusion of the base 2.

[0052]

If the pigment-comprising layer 5 is composed, on the other hand, by including another component in addition to the pigment, a binder, inorganic powder, lubricant, or other substance that can be included in the pigment-comprising layer in the magnetic tape of the first embodiment can be used as the other component. The details and amounts of these components are similar to those associated with the first embodiment and will therefore not be discussed in particular, but the explanation provided in detail with regard to the first embodiment is applicable as appropriate. Including the inorganic powder, and especially powder A and powder B, is preferable because it allows an anti-electrostatic function to be conferred to the pigment-comprising layer 5 and, as will be discussed later, prevents displacement at the interface between the two layers when the pigment-comprising layer 5 and the backcoating layer are formed by simultaneous application with a wet-on-wet method. The pigment-comprising layer 5 containing these components is formed by applying a pigment-comprising coating composition comprising these components dispersed in a solvent on the base. The details of the pigment-comprising coating composition are similar to those associated with the first embodiment and will therefore not be discussed in particular, but the explanation provided in detail with regard to the first embodiment is applicable as appropriate.

[0053]

The thickness of the pigment-comprising layer 5 in this embodiment can be made thinner than the pigment-comprising layer in the magnetic tape of the first embodiment because the pigment-comprising layer 5 does not double as a backcoating layer—it is preferably 30 to 200 nm and particularly 50 to 150 nm.

[0054]

The backcoating layer 6 preferably includes a binder, inorganic powder (particularly powder A and B), lubricant, hardener, or other substance so that the functions traditionally associated with a backcoating layer of a magnetic tape are expressed. The details of these components are similar to those associated with the first embodiment and will therefore not be discussed in particular, but the explanation provided in detail with regard to the first embodiment is applicable as appropriate. The amount of these materials included in the backcoating layer 6 per 100 parts by weight of the binder is preferably within the following ranges:

- Inorganic powder: 50 to 800 parts by weight, particularly 70 to 700 parts by weight
- Lubricant: 0 to 20 parts by weight, particularly 0 to 10 parts by weight
- Hardener: 0 to 40 parts by weight, particularly 5 to 30 parts by weight

And similarly to the first embodiment, the inorganic powder, particularly the electrically conducting inorganic powder included in the backcoating layer 6 preferably is light transmitting in order to make the light transmittance of the magnetic tape as a whole within the above range. Therefore, the inorganic powder preferably has a non-black hue and a small particle diameter within an appropriate range. Specifically, the particle diameter of the inorganic powder is preferably 1 to 100 nm, particularly 2 to 10 nm, and especially 5 to 50 nm. In addition, both an inorganic powder with such a particle diameter and an inorganic powder with a particle diameter of 50 to 700 nm (e.g., inorganic powder B) can be used together to further confer running characteristics to the backcoating layer 5 [sic].

[0055]

The backcoating layer 6 is formed by applying a backcoating composition comprising the above components dispersed in a solvent to the pigment-comprising layer 5. In this case, when the pigment-comprising layer 5 is being formed by coating a composition with a pigment dissolved in a solvent (the composition in method (2) above) or the pigment-comprising coating composition, which contains a pigment, a binder, carbon black, and other substance, the composition that comprises the pigment and the backcoating composition can be applied with either a consecutive application coating method or a simultaneous application coating method. A consecutive application coating method, however, has low productivity, and pigment from the pigment-comprising layer 5 could elute and mix with the backcoating composition at the time of consecutive application, so it is preferable to employ a wet-on-wet, simultaneous application coating method that does not carry this concern and features high productivity.

[0056]

In the magnetic tape 1 of the third embodiment shown in Fig. 7, a discoloration pattern in which servo signals are recorded is formed in a pigment-comprising layer 5 in advance of the use of the magnetic tape similarly to the magnetic tape of the first embodiment. With regard to the points of the magnetic tape 1 of this embodiment that differ from those of the magnetic tape of the first embodiment, a thin metal layer 7 is further formed between the base 2 (e.g., a plastic film) and the pigment-comprising layer 5 or a second thin metal layer 8 is further formed between the base 2 and the intermediate layer 3, and light of a specified wavelength is illuminated at a discoloration pattern 10 from the side with the pigment-comprising layer in the magnetic tape 10 [sic] and the reflected light is detected to allow the servo signals, indicated by the intensity of the detected light, to be read. In other words, in the magnetic tape of the first embodiment, servo signals can be read with transmitted light, while in the magnetic tape 1 of this embodiment, a compound construction comprising a thin metal layer formed on the base 2 (plastic film) is used as a new base, and servo tracking is performed by reading servo signals with reflected light. One of the thin metal layers 7, 8 provided alone can serve as a light-reflecting layer, but in this case, the functional balance with the base 2 (plastic film) is lost and there is the possibility of curling, so it is preferable to provide a thin metal layer on both sides of the base 2 (plastic film).

[0057]

Servo tracking in this embodiment will be discussed with reference to Fig. 8. Herein, Fig. 8 is a schematic view illustrating a servo tracking method in which the intensity of reflected light is detected and corresponds to Fig. 4(a) of the first embodiment. Note that in Fig. 8, the intermediate layer 3 and the magnetic layer 4 in the magnetic tape shown in Fig. 7 are omitted.

[0058]

The servo tracking method shown in Fig. 8 employs a push-pull method similarly to the servo tracking method shown in Fig. 4. In detail, as Fig. 8 shows, light from a light source 30, such as a semiconductor laser, provided in opposition to the pigment-comprising layer 5 in magnetic tape running perpendicular to the surface of the paper is condensed into a beam-like state of a specified diameter by a lens 31, passes through a semitransparent mirror 37, and then enters a discoloration pattern 10 formed in the pigment-comprising layer 5. At this time, the beam diameter is slightly smaller than the width of the discoloration pattern 10. Light passing through the discoloration pattern 10 reflects at the thin metal layer 7 and proceeds in the direction opposite that in which it entered. This reflected light is again reflected by the semitransparent mirror 37, the direction of travel changes, and it enters a light detector 33. In addition, the intensity of the reflected light is detected by the light detector 33. The reflected light detected corresponds to the servo signals recorded in the discoloration pattern 10, and the reflected light is converted into electrical signals in the light detector 33 and sent to a servo tracking processing device 34. Subsequent servo signal processing takes place similarly to the situation shown in Fig. 4 and as such will not be discussed in particular, but the detailed description regarding Fig. 4 is applicable as appropriate.

[0059]

A substance of a high light reflectivity is preferably employed as the materials that constitute the thin metal layers 7, 8, with examples such as an alloy consisting primarily of Au, Al, Ag, and these (?) being preferably used. The materials constituting the thin metal layers 7, 8 can be identical or different.



[0060]

The thin metal layers 7, 8 are preferably each formed with a commonly known means for thin-film formation that uses vacuum film formation. The use of such a film formation method greatly improves the corrosion resistance of the formed thin metal layers 7, 8 and provides a magnetic tape with excellent storage durability.<sup>6</sup> Examples of such vacuum film formation methods are vacuum vapor deposition, sputtering, and ion implanting, and the method used is appropriately selected according to the material and other properties of the thin metal layers 7, 8 and used.

[0061]

The thickness of the thin metal layers 7, 8 should be of a level adequate to reflect incoming light and is preferably 0.01–1  $\mu\text{m}$  and particularly 0.02 to 0.7  $\mu\text{m}$ . The thicknesses of the thin metal layers 7, 8 can be identical or different.

[0062]

The reflectivity before servo signal recording of the pigment-comprising layer 5 in the magnetic tape of this embodiment is preferably at least 5%, particularly at least 10%, and especially at least 15% at the wavelength of light used for the reading of the servo signals. There is no particular upper limit for light reflectivity, which is preferably as high as possible, but the practical upper limit is around 70%.

[0063]

In the magnetic tape 1 of this embodiment, the thin metal layer 7 is formed on the side with the pigment-comprising layer 5, and the thin metal layer 7 functions in electrostatic prevention in addition to functioning as a reflective film, so, in contrast to the magnetic tape 1 of the first embodiment, the carbon black and the electrically conducting inorganic microparticles need not be included as anti-electrostatic agents in the pigment-comprising layer 5. As a result, the light transmittance of the pigment-comprising layer 5 becomes greater than the light transmittance of the pigment-comprising layer in the magnetic tape 1 of the first embodiment, and the intensity of reflected light increases, so servo tracking can be performed even more accurately.

[0064]

The magnetic tape 1 of the fourth embodiment shown in Fig. 9 comprises thin metal layers 7, 8 on both sides of the base as does the magnetic tape of the third embodiment, and the embodiment is configured such that servo signals are read using reflected light to perform servo tracking. With regard to the points of the magnetic tape 1 of this embodiment that differ from those of the magnetic tape of the third embodiment, the pigment-comprising layer of the third embodiment doubles as a backcoating layer, while in the magnetic tape 1 of the fourth embodiment, a backcoating layer 6 adjoins the pigment-comprising layer 5 and is formed as the outermost layer independent from the pigment-comprising layer 5. The configuration of the pigment-comprising layer 5 and the backcoating layer 6 are similar to those of the second embodiment. That is, the magnetic tape 1 of this embodiment is a combination of the pigment-comprising layer 5 and the backcoating layer 6 of the second embodiment and the thin metal layers 7, 8 of the third embodiment. So with regard to the details of these layers in the magnetic tape of this embodiment, the description of the corresponding parts in the second embodiment and the third embodiment are applicable as appropriate.

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<sup>6</sup> That is, information on the tape lasts a long time.

[0065]

In the magnetic tape 1 in this embodiment, as is the case in the second embodiment, the pigment-comprising layer 5 functions in the recording and reading of servo signals, while the backcoating layer 6 serves the traditional function of a backcoating layer to allow division of functions, thus providing a greater degree of design freedom to the magnetic tape 1 than was the case with the first embodiment. And similarly to the third embodiment, a thin metal layer 7 serves as a reflective film and also acts in electrostatic prevention, so the carbon black and the electrically conducting inorganic microparticles need not be included as anti-electrostatic agents in the pigment-comprising layer 5 and the backcoating layer 6. As a result, the light transmittance of the pigment-comprising layer 5 and the backcoating layer 6 becomes greater than the light transmittance of the pigment-comprising layer and the backcoating layer in the magnetic tape of the second embodiment, and the intensity of reflected light increases, so servo tracking can be performed even more accurately. In this embodiment, as in the third embodiment, reflectivity before servo signal recording of the pigment-comprising layer 5 in the magnetic tape of this embodiment is preferably at least 5%, particularly at least 10%, and especially at least 15% at the wavelength of light used for the reading of the servo signals.

[0066]

Next, general items common to the magnetic tape of each of the embodiments will be described.

[0067]

The magnetic layer 4 of the magnetic tape 1 of each embodiment is formed by applying a magnetic coating material comprising ferromagnetic powder and a binder. In other words, the magnetic tape 1 is coated magnetic tape.

[0068]

Examples of ferromagnetic powders that can be used are acicular or spindle-shaped ferromagnetic powder and tabular ferromagnetic powder. Acicular or spindle-shaped ferromagnetic powder includes ferromagnetic metal powder consisting primarily of iron as well as ferromagnetic iron oxide powder. An example of tabular ferromagnetic powder is ferromagnetic hexagonal ferrite powder.

[0069]

In greater detail, the ferromagnetic metal powder includes powder having a metal content of 50% by weight or more, 50% by weight or more of the metal content being iron. Specific examples of such ferromagnetic metal powders include Fe-Co, Fe-Ni, Fe-Al, Fe-Ni-Al, Fe-Co-Ni, Fe-Ni-Al-Zn, and Fe-Al-Si. The ferromagnetic iron oxide powder includes  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>, Co-coated  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>, and Co-coated  $\gamma$ -Fe<sub>2</sub>O<sub>x</sub> ( $4/3 \leq x < 1.5$ ). The acicular or spindle-shaped ferromagnetic powder preferably has a major axis length of 0.03 to 0.2  $\mu$ m and particularly 0.05 to 0.16  $\mu$ m, with an acicular ratio (i.e., major axis length to minor axis length) of 3 to 15 and particularly 3 to 10. The coercive force (Hc) thereof is preferably 125 to 200 kA/m and particularly 135 to 190 kA/m, and the saturation magnetization ( $\sigma_s$ ) is preferably 119 to 167 Am<sup>2</sup>/kg and particularly 127 to 152 Am<sup>2</sup>/kg. The BET specific surface area of the acicular ferromagnetic powder is preferably 30 to 70 m<sup>2</sup>/g and particularly 40 to 70 m<sup>2</sup>/g.

[0070]

The ferromagnetic hexagonal ferrite powder includes minute tabular magnetic particles of barium ferrite, strontium ferrite, or those substances with part of the Fe atoms replaced with Ti, Co, Ni, Zn, V or similar atoms. The ferromagnetic hexagonal ferrite powder preferably has a tabular diameter of 0.1  $\mu$ m or less, particularly 10 to 90 nm, and especially 10 to 40 nm. The tabular ratio (tabular diameter to tabular thickness) is preferably 2 to 7 and particularly 2 to 5. The coercive force (Hc) thereof is preferably 135 to 260 kA/m, and the saturation magnetization ( $\sigma_s$ ) is preferably 27 to 72 Am<sup>2</sup>/kg and particularly 43 to 72 Am<sup>2</sup>/kg. Moreover, the BET specific surface area of the ferromagnetic hexagonal ferrite powder is preferably 30 to 70 m<sup>2</sup>/g.

[0071]

If necessary, the ferromagnetic powder can contain rare earth elements or transition metal elements. Moreover, surface treatment can be performed on the ferromagnetic powder to improve dispersibility and similar properties. Examples of such surface treatment are a method in which the surface of the ferromagnetic particles is coated with an inorganic oxide and a similar method. Examples of inorganic oxides that can be used in such a case are  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{TiO}_2$ ,  $\text{ZrO}_2$ ,  $\text{SnO}_2$ ,  $\text{Sb}_2\text{O}_3$ , and  $\text{ZnO}$ , and these inorganic oxides can be used either individually or as a mixture of two or more. Other than the above method, the surface treatment can also be performed by an organic treatment, such as a silane coupling treatment, a titanium coupling treatment, or an aluminum coupling treatment.

[0072]

A substance similar to that presented as an example of the binder used to form the pigment-comprising layer 5 and the backcoating layer 6 can be used as the above binder. Therefore, the details of this binder will not be discussed in particular, but the explanation detailing the pigment-comprising layer 5 and the backcoating layer 6 is applicable as appropriate. The binder is preferably added at 10 to 40 parts by weight and particularly 15 to 25 parts by weight per 100 parts by weight of the ferromagnetic powder.

[0073]

The magnetic layer 4, in addition to the components noted above, can contain abrasive particles, carbon black, a lubricant, a hardener, or another such substance.

[0074]

A powder of a substance having a Mohs hardness of 7 or higher, such as alumina, silica,  $\text{ZrO}_2$ , or  $\text{Cr}_2\text{O}_3$ , is preferably used as the abrasive particles. From the standpoint of reduction in the frictional coefficient during running and better running durability, the particle diameter of the abrasive particles is preferably 0.03 to 0.6  $\mu\text{m}$  and more preferably 0.05 to 0.3  $\mu\text{m}$ . The abrasive particles are preferably added in an amount of 2 to 20 parts by weight and particularly 3 to 15 parts by weight per 100 parts by weight of the ferromagnetic powder.

[0075]

Substances similar to those used to form the pigment-comprising layer 5 and the backcoating layer 6 can be used as the above carbon black, lubricant, and hardener. Therefore, the details of these components will not be discussed in particular, but the explanation detailing the pigment-comprising layer 5 and the backcoating layer 6 are applicable as appropriate. The carbon black is preferably added in an amount of 0.1 to 10 parts by weight and particularly 0.1 to 5 parts by weight per 100 parts by weight of the ferromagnetic powder. The lubricant is preferably added in an amount of 0.5 to 10 parts by weight and particularly 0.5 to 5 parts by weight per 100 parts by weight of the ferromagnetic powder. The hardener is preferably added in an amount of 2 to 30 parts by weight and particularly 5 to 20 parts by weight per 100 parts by weight of the ferromagnetic powder.

[0076]

As required, various additives normally used in magnetic tape, such as dispersants, rust inhibitors, and antifungals, can be added to the magnetic layer 4 in addition to the above-described components.

[0077]

The magnetic layer 4 is formed by applying on an intermediate layer 3 a magnetic coating composition with the above components dispersed in a solvent. A solution similar to those described as an example of the solvents used for the pigment-comprising coating composition and the backcoating composition can be used as the solvent. The amount of solvent in the magnetic coating composition is preferably 80 to 500 parts by weight and particularly 100 to 350 parts by weight per 100 parts by weight of the ferromagnetic powder included in the magnetic coating composition.

[0078]

To prepare the magnetic coating composition, the ferromagnetic powder and the binder are preliminarily mixed together with a portion of the solvent in a Naughter mixer, etc. to obtain a mixture, the mixture is kneaded in a continuous pressure kneader, a twin-screw kneader, or a similar machine, [the mixture] is diluted with a portion of the solvent and dispersed with a sand mill or similar implement, the lubricant or another additive is added, filtering is performed, and the remainder of the solvent and the hardener are added, for example.

[0079]

From the standpoint of contributing to adequate recording and playback characteristics, the coercive force of the magnetic layer formed from the magnetic coating composition is preferably 119 to 280 kA/m (1495 to 3519 Oe), more preferably 120 to 250 kA/m (1508 to 3141 Oe), and even more preferably 125 to 222 kA/m. The saturation magnetic flux of the magnetic layer 4 is preferably 0.1 to 0.5 T and particularly 0.15 to 0.45 T.

[0080]

From the standpoint of a better S/N and for preventing self-demagnetization, the thickness of the magnetic layer 4 is preferably 0.01 to 1  $\mu\text{m}$ , more preferably 0.05 to 0.8  $\mu\text{m}$  [sic], and particularly preferably 0.05 to 0.3  $\mu\text{m}$ .

[0081]

Next, the intermediate layer 3 is discussed.

The intermediate layer 3 may be either a layer having magnetism or a nonmagnetic layer. When the intermediate layer 3 is a layer having magnetism, the intermediate layer 3 is a magnetic layer containing magnetic powder and is formed by using a magnetic coating material primarily comprising magnetic powder, nonmagnetic powder, a binder, and a solvent. When, on the other hand, the intermediate layer 3 is a nonmagnetic layer, the intermediate layer 5 [sic] is formed by using a nonmagnetic coating material primarily comprising nonmagnetic powder, a binder, and a solvent. (These coating materials will be generally referred to as an "intermediate layer coating material.")

[0082]

Ferromagnetic powder is preferably used as the magnetic powder. Both hard magnetic powder and soft magnetic powder are used preferably as the ferromagnetic powder.

[0083]

The hard magnetic powder can be, for example, the ferromagnetic hexagonal ferrite powder, ferromagnetic metal powder, and ferromagnetic iron oxide powder used in the magnetic layer 4. Details regarding these magnetic powders will not be discussed because they are similar to the ferromagnetic powders used in the magnetic layer 4, but a discussion regarding the strong magnetic powder is appropriately applied.

[0084]

While there are no particular limits with regard to the soft magnetic powder, a substance generally used in so-called low-current devices, such as a magnetic head or electronic circuit, is preferred, and, for example, the soft magnetic materials described in *Chikazumi Toshinobu, Kyojiseitai no Butsuri (2nd Vol.) Jikitokusei to Ohyo*, pp. 368–376, Shokabo (1984) can be used—specifically, soft magnetic oxide powder and soft magnetic metal powder can be used. Spinel type ferrite powder is preferably used as the soft magnetic oxide powder. Although there are no particular limits on the shape of the soft magnetic powder, examples are a spherical shape, a tabular shape, and an acicular shape, and the size of the particles is preferably 5 to 800 nm.

[0085]

As necessary, the above magnetic powder can contain rare earth elements or transition metal elements similarly to the ferromagnetic powder contained in the magnetic layer 4, and further, a surface treatment similar to the surface treatment given to the ferromagnetic metal powder may be performed.

[0086]

A powder of an inorganic substance having a Mohs hardness of less than 6 is preferably used as the non-metallic powder, and examples thereof are a powder of nonmagnetic iron oxide (red oxide), barium sulfate, zinc sulfide, magnesium carbonate, calcium carbonate, calcium oxide, zinc oxide, magnesium oxide, magnesium dioxide, tungsten disulfide, molybdenum disulfide, boron nitride, tin dioxide, silicon carbide, cerium oxide, corundum, artificial diamond, garnet, siliceous stone, silicon nitride, molybdenum carbide, boron carbide, tungsten carbide, titanium carbide, diatomaceous earth, dolomite, and resins. Of these, nonmagnetic iron oxide (red oxide), titanium oxide, and boron nitride are preferably used. These nonmagnetic powders can be used either individually or as a combination of two or more. The shape of the nonmagnetic particles may be any of a spherical shape, a tabular shape, an acicular shape, or an amorphous shape. As for size, spherical, tabular, and amorphous particles preferably have a particle diameter of 5 to 200 nm, and acicular particles preferably have a major axis length of 20 to 300 nm with an acicular ratio of 3 to 20. When the nonmagnetic powder is used in combination with the magnetic powder (i.e., when the intermediate layer 3 is a magnetic layer), it is preferably used in an amount of 30 to 70 parts by weight and more preferably 40 to 60 parts by weight per 100 parts by weight of the magnetic powder. On the other hand, when the magnetic powder is not used (i.e., when the intermediate layer 3 is a nonmagnetic layer), the amounts of the other components are decided based on 100 parts by weight of the nonmagnetic powder. If necessary, the above various nonmagnetic powders can be subjected to the same surface treatment as is performed for the magnetic powder.

[0087]

The intermediate layer 3, whether magnetic or nonmagnetic, can contain a binder in addition to the above components and may further contain abrasive particles, lubricants, carbon black, hardeners, and similar substances. Although these components are not described specifically, they are similar to those used for the pigment-comprising layer 5, the backcoating layer 6, and magnetic layer 4. Preferred amounts of these components are shown below, given in terms of parts by weight per 100 parts by weight of the total amount of the magnetic powder and the nonmagnetic powder (where the intermediate layer 3 is a magnetic layer) or 100 parts by weight of the nonmagnetic powder (where the intermediate layer 3 is a nonmagnetic layer).

- Binder: 8 to 40 parts by weight, particularly 10 to 25 parts by weight
- Abrasive particles: 1 to 30 parts by weight, particularly 1 to 12 parts by weight
- Lubricant: 0.5 to 20 parts by weight; particularly 1 to 7 parts by weight
- Carbon black: 0.5 to 30 parts by weight, particularly 2 to 10 parts by weight
- Hardener: 0.5 to 12 parts, particularly 2 to 8 parts by weight

As necessary, the intermediate layer 3 can contain various substances similar to the additives added to the magnetic layer 4.

[0088]

The intermediate layer 3 is formed by applying an intermediate layer coating composition containing the above various components and a solvent to the base 2. The solvent used is similar to those added to the pigment-comprising composition, the backcoating composition, and the magnetic coating composition. The amount of the solvent to be used is preferably 100 to 700 parts by weight and particularly preferably 300 to 500 parts by weight per 100 parts by weight of the total of the magnetic powder and the nonmagnetic powder (when the intermediate layer 3 is a magnetic layer) or 100 parts by weight of the nonmagnetic powder (when the intermediate layer 3 is a nonmagnetic layer).

[0089]

The thickness of the intermediate layer 3 must have some thickness from the standpoint of controlling the holding capacity of the lubricant, which affects the durability of the magnetic tape 1, but too great a thickness results in the ready occurrence of cracking during deformation, so a thickness of 0.5 to 10  $\mu\text{m}$  and particularly 0.1 to 3  $\mu\text{m}$  is preferable.

[0090]



When the intermediate layer 3 is a layer having magnetism, the coercive force thereof preferably is within 80 to 350 kA/m and particularly 150 to 300 kA/m from the standpoints of overwrite characteristics and low- and high-range output balance. The saturation flux density thereof is preferably 0.04 to 0.5 T and particularly 0.05 to 0.4 T from the standpoint of a balance between the low and high regions of output.

[0091]

Materials constituting the base 2 are nonmagnetic materials including polymer resins such as polyesters such as polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polycyclohexylene dimethylene terephthalate, and polyethylene bisphenoxycarboxylate; polyolefins such as polyethylene and polypropylene; cellulose derivatives, such as cellulose acetate butyrate and cellulose acetate propionate; vinyl resins such as polyvinyl chloride and polyvinylidene chloride; polyamide; polyimide; polycarbonate; polysulfone; polyether ether ketone; and polyurethane. These materials can be used individually or in combination of two or more. If necessary, the base made of these materials can be subjected to uniaxial or biaxial stretching, a corona discharge treatment, an adhesion-improving treatment, or the like.

[0092]

There are no particular limits on the thickness of the base 2, but the base 2 is preferably thin, given that the magnetic tape of the invention is suited particularly as a high-capacity magnetic tape, and specifically 1 to 13  $\mu\text{m}$  and particularly 1 to 8  $\mu\text{m}$  are preferable.

[0093]

Next, an outline of a preferred method for manufacturing the magnetic tape 1 is described by taking as an example the manufacture of the magnetic tape 1 of the first embodiment shown in Fig. 1.

First, a magnetic coating composition for forming the magnetic layer 4 and an intermediate layer coating composition for forming the intermediate layer 3 are applied simultaneously to the base 2 with a wet-on-wet system so that each layer is of a specified thickness in order to form coating layers of the magnetic layer 4 and the intermediate layer 3. In other words, the magnetic layer 4 is preferably coated and formed while the intermediate layer 3 is wet.

Then, the coating layers are subjected to magnetic field orientation, dried, and wound. Thereafter, the coated material is calendered, and the pigment-comprising composition is applied to the back surface of the base 2 to form the pigment-comprising layer 5. Alternatively, the intermediate layer 3 and the magnetic layer 4 may be formed after the pigment-comprising layer 5 is formed. The coated material is aged at 40 to 80°C for 6 to 100 hours and then slit to a prescribed width to obtain the magnetic tape 1. When the magnetic tape is to be used, a specified discoloration pattern 10 in which servo signals are recorded is formed on the backcoating layer 5 using the above method.

[0094]

The superimposing coating technique in the wet-on-wet system is described on column 42, line 31 to column 43, line 31 of Japanese Unexamined Patent Application Publication H5-73883—it is a method in which a magnetic coating composition is applied before an intermediate layer coating composition dries. With this method, magnetic tape that causes few dropouts, is compatible with high-density recording, and has coating layers of excellent durability is obtained.

[0095]

The magnetic field orientation treatment is carried out before each coating composition dries and is executed with a method that applies a magnetic field of about 40 kA/m or higher, preferably about 80 to 800 kA/m, in parallel with the surface coated with the magnetic coating composition or method that passes [the coated material] through a solenoid type magnet of about 80 to 800 kA/m while the magnetic coating composition is wet. By performing the magnetic field orientation treatment under such conditions, the ferromagnetic powder in the magnetic layer 4 can be orientated in the lengthwise direction of the magnetic tape 1. So that the thus orientated ferromagnetic powder does not change its orientation during drying following magnetic field orientation, warm air of 30 to 50°C is preferably blown from above the magnetic layer 4 immediately before the magnetic field orientation to bring about preliminary drying and control the amount of solvent remaining in the layers.

[0096]

Drying treatment is carried out by, for example, supplying a gas heated to 30 to 120°C, and at this time, the extent of the drying of the coated layers can be controlled by adjusting the temperature and the supply rate of the gas.

[0097]

The calendering can be performed by supercalendering or a similar method in which [the coated film] is passed between two rolls, such as a combination of a metal roll and a cotton roll or a synthetic resin roll, or two metal rolls. The calendering conditions are preferably, for example, 60 to 140°C and 1 to 5 kN/cm in linear pressure.

[0098]

In the manufacture of the magnetic tape 1, the surface of the magnetic layer 4 can be subjected to a finishing step, such as burnishing or cleaning, as necessary. The magnetic coating composition and the intermediate layer coating composition can also be applied with a generally known successive coating technique.

[0099]

Although the magnetic tape of the invention has been described based on the preferred embodiments thereof, the invention is not limited to the embodiments, and various modifications can be made within a range that does not depart from the spirit of the invention.

For example, the magnetic tape 1 of the embodiments shown in Figs. 1, 6, 7 and 9 is in each case magnetic tape with a multi-layer construction in which a magnetic layer 4 and an intermediate layer 3 are formed on a base 2, but alternatively, it could be made a magnetic tape with a single-layer construction in which a magnetic layer 4 alone is formed on a base as shown in Figs. 10 to 13.

And in the magnetic tape 1 of the embodiments shown in Figs. 7, 9, 12, and 13, a second thin metal layer 8 formed on the side with the magnetic layer may be omitted.

And in the magnetic tape 1 of the embodiments shown in Figs. 1, 6, 10, and 11, servo signals are read primarily through the use of transmitted light, but if a layer with an appropriate reflectivity or birefringence is used as the pigment-containing layer 5 or the backcoating layer 6, reflected light could be used to read the servo signals.

And in the above embodiments, a combination of a single or plurality of a discoloration pattern 10 comprising a continuous line along the lengthwise direction of the magnetic tape 1 and a discoloration pattern 10 comprising a discontinuous line of a specified width along the lengthwise direction of the magnetic tape 1 could be used.

Moreover, a straight or curved dotted line or a combination of the two could be used as the discoloration pattern 10.

In addition, a circular, oval, or other shape or a combination thereof could also be used as the discoloration pattern 10.

In the magnetic tape 1 of the embodiments shown in Figs. 1 and 6, a primer layer could be provided between the base and either the intermediate layer 3 or the pigment-comprising layer 5.

Furthermore, while the above embodiments are coated magnetic tapes, equivalent effects would come through the use of a metal-vapor-deposition-type magnetic tape instead.

[0100]

*Working Examples*

Below, the magnetic tape of the invention will be discussed in greater detail, and the efficacy thereof will be validated through working examples. However, the invention is not limited to the working examples. In the working examples, the viscosity of the pigment-comprising coating composition (viscosity as determined with an E-type viscosity meter at 100 rpm) is based on Working Example I-1, and the viscosity of the pigment-comprising coating compositions of the other working examples and comparative examples were adjusted by appropriately increasing or decreasing the amount of solvent so that the viscosity would be plus or minus 30% of the viscosity of the pigment-comprising coating composition of Working Example I-1. Unless otherwise specified, all the parts and percents are parts by weight and percentages by weight, respectively.

[0101]

*Working Example I-1*

The following components (except the hardener) were individually kneaded in a kneader, dispersed in a stirrer, further finely dispersed in a sand mill, and filtered through a 1- $\mu$ m filter, and then the hardener was added to prepare a pigment-comprising coating composition, a magnetic coating composition, and an intermediate layer coating composition having the formulations described below.

[0102]

*Formulation of Pigment-Comprising Coating Composition*

Indium-doped tin oxide (ITO)	100 parts
(mean particle diameter: 35 nm)	
Silicone particles (mean particle diameter: 0.5 $\mu$ m)	3 parts
[Tospearl 105 (product name) by Toshiba Silicone]	
Phosphate ester (lubricant)	3 parts
(Phosphanol RE610 (product name) by Toho Chemical)	
3,3'-dipropylthiadicarbocyanine iodide (pigment)	0.3 parts
Polyurethane resin (binder)	28 parts
(number average molecular weight: 25,000; sulfoxyl group content: $1.2 \times 10^{-4}$ M/g; glass transition point: 45°C)	

Stearic acid (lubricant)	0.5 parts
Polyisocyanate (hardener)	4 parts
(Coronate L (product name) by Nippon Polyurethane Industry Co., Ltd.); solid content: 75%	
Methyl ethyl ketone (solvent)	120 parts
Toluene (solvent)	80 parts
Cyclohexanone (toluene)	40 parts

[0103]

*Formulation of Magnetic Coating Composition*

Acicular ferromagnetic powder containing primarily iron	100 parts
(Fe:Co:Al:Y:Ba ratio: 70:25:2:2:1 (by weight)) (major axis length: 0.07 $\mu\text{m}$ ; axis ratio: 6; coercive force: 160 kA/m (2010 Oe); saturation magnetization: 142 $\text{Am}^2/\text{kg}$ ; specific surface area: 56 $\text{m}^2/\text{g}$ ; X-ray particle diameter: 0.014 $\mu\text{m}$ )	
Alumina (abrasive; mean particle diameter: 0.15 $\mu\text{m}$ )	8 parts
Carbon black	0.5 parts
(mean primary particle diameter: 0.018 $\mu\text{m}$ )	
[Poly]vinyl chloride copolymer (binder)	10 parts
(mean degree of polymerization: 280; epoxy group content: 1.2% by weight; sulfoxyl group content: $8 \times 10^{-5}$ equiv./g)	
Polyurethane resin (binder)	7 parts
(number average molecular weight: 25,000; sulfoxyl group content: $1.2 \times 10^{-4}$ equiv./g; glass transition point: 45°C)	
Stearic acid (lubricant)	1.5 parts
2-ethylhexyl oleate (lubricant)	2 parts
Polyisocyanate (hardener)	5 parts
(Coronate L (product name) by Nippon Polyurethane Industry Co., Ltd.; solid component: 75%)	
Methyl ethyl ketone	120 parts

Toluene	80 parts
Cyclohexanone	40 parts

[0104]

*Formulation of Intermediate Layer Coating Composition*

Acicular $\alpha$ -Fe <sub>2</sub> O <sub>3</sub>	100 parts
(mean particle diameter (major axis length): 0.12 $\mu$ m, axis ratio: 10; specific surface area: 48 m <sup>2</sup> /g)	
Alumina (abrasive; primary particle diameter: 0.15 $\mu$ m)	3 parts
Vinyl chloride copolymer (binder)	12 parts
(average degree of polymerization: 280; epoxy group content: 1.2 wt %; sulfoxyl group content: $8 \times 10^{-5}$ equiv./g)	
Polyurethane resin (binder)	8 parts
(number average molecular weight: 25,000; sulfoxyl group content: $1.2 \times 10^{-4}$ equiv./g; glass transition point: 45°C)	
Stearic acid (lubricant)	1 part
2-ethylhexyl oleate (lubricant)	4 parts
Polyisocyanate (hardener)	4 parts
(Coronate L (product name) produced by Nippon Polyurethane Industry Co., Ltd.; solid component: 75%)	
Methyl ethyl ketone	90 parts
Toluene	60 parts
Cyclohexanone	30 parts

[0105]

The intermediate layer coating composition and the magnetic coating composition were applied simultaneously on a the base comprising a 6- $\mu$ m thick polyethylene naphthalate film by means of a die coater so that the dry thicknesses of the intermediate layer and the magnetic layer were 1.5  $\mu$ m and 0.2  $\mu$ m, respectively. Next, the coated films were passed through a solenoid type magnet of 400 kA/m while wet to perform magnetic orientation. Moreover, [they] were dried in a drying oven by blowing hot air of 80°C at a rate of 10 m/min. After the drying, the coated film was calendered to form an intermediate layer and a magnetic layer. Subsequently, the reverse side of the base was coated with the pigment-comprising coating composition and dried at 90°C to form a pigment-comprising layer having a thickness of 1.0  $\mu$ m. The resulting magnetic tape stock was slit tape with a width of 12.7 mm to obtain magnetic tape of the construction shown in Fig. 1. The coercive force of the magnetic layer in the obtained magnetic tape was 165 kA/m (2073 Oe), the saturation magnetic flux density was 0.37 T, the angle ratio was 0.86, the arithmetic average roughness Ra was 4.3 nm, and the 10 point average roughness Rz was 41 nm.

[0106]

Next, as shown in Fig. 2, a plurality of discoloration patterns recorded with servo signals was formed on the pigment-comprising layer by shining a laser beam at the pigment-comprising layer of the resulting magnetic tape. The formation conditions of the discoloration patterns were as follows: the laser beam wavelength was 1020 nm, the output was 50 mW and the beam diameter was 2  $\mu$ m. The discoloration patterns thus formed were linear, parallel to the lengthwise direction of the magnetic tape, and continuous, and they were formed with equal spacing across the widthwise direction of the magnetic tape.

[0107]

*Working Example I-2*

The magnetic tape was obtained similarly to Working Example I-1, and the discoloration patterns were formed similarly to Working Example I-1 on the pigment-comprising layer of the magnetic tape except that the amount of ITO added to the pigment-comprising coating composition used in Working Example I-1 was set at 70 parts, the pigment was set at 0.6 parts, and 30 parts of spherical magnetite with a mean particle diameter of 80 nm was added.

[0108]

*Working Example I-3*

The magnetic tape was obtained similarly to Working Example I-1, and the discoloration patterns were formed similarly to Working Example I-1 on the pigment-comprising layer of the magnetic tape except that the silicone particles added to the pigment-comprising coating composition used in Working Example I-1 were not added.

[0109]

*Working Example I-4*

The magnetic tape was obtained similarly to Working Example I-1, and the discoloration patterns were formed similarly to Working Example I-1 on the pigment-comprising layer of the magnetic tape except that crystal violet was used in place of the pigment in the pigment-comprising coating composition used in Working Example I-1.

[0110]

*Working Example I-5*

The magnetic tape was obtained similarly to Working Example I-1, and the discoloration patterns were formed similarly to Working Example I-1 on the pigment-comprising layer of the magnetic tape except that thionine was used in place of the pigment in the pigment-comprising coating composition used in Working Example I-1.

[0111]

*Working Example I-6*

The magnetic tape was obtained similarly to Working Example I-1, and the discoloration patterns were formed similarly to Working Example I-1 on the pigment-comprising layer of the magnetic tape except that the amount of ITO added to the pigment-comprising coating composition used in Working Example I-1 was set at 50 parts, and 50 parts of  $\text{TiO}_2$  with a mean particle diameter of 30 nm was added.

[0112]

*Working Example I-7*

The magnetic tape was obtained similarly to Working Example I-1, and the discoloration patterns were formed similarly to Working Example I-1 on the pigment-comprising layer of the magnetic tape except that the amount of silicone particles added to the pigment-comprising coating composition used in Working Example I-1 was set at 6 parts.

[0113]

*Working Example I-8*

The magnetic tape was obtained similarly to Working Example I-1, and the discoloration patterns were formed similarly to Working Example I-1 on the pigment-comprising layer of the magnetic tape except that the amount of ITO added to the pigment-comprising coating composition used in Working Example I-1 was set at 10 parts, and 90 parts of  $\alpha\text{-Fe}_2\text{O}_3$  with a mean particle diameter of 20 nm was added.

[0114]

*Comparative Example I-1*

The magnetic tape was obtained similarly to Working Example I-1 except that the pigment added to the pigment-comprising coating composition used in Working Example I-1 was not added.

[0115]

*Comparative Example I-2*

The magnetic tape was obtained similarly to Working Example I-1 except that a backcoating composition prepared from the following components was used in place of the pigment-comprising coating composition used in Working Example I-1.



Carbon black	40 parts
(Electrostatic preventing agent, mean primary particle diameter: 0.018 $\mu\text{m}$ )	
Nippouran 2301 (binder)	50 parts
(product name; Nippon Polyurethane Industry Co., Ltd. (solid content: 40%))	
Polyisocyanate (hardener)	4 parts
(Coronate L (product name) produced by Nippon Polyurethane Industry Co., Ltd.; solid content: 75%)	
Nitrocellulose	20 parts
Stearic acid	1 part
Methyl ethyl ketone	140 parts
Toluene	140 parts
Cyclohexanone	140 parts

[0116]

To evaluate the performance of the magnetic tapes obtained in the working and comparative examples, the reproduction output of the magnetic tape; light transmittance and kinetic coefficient of friction of the pigment-comprising layer, and electrical surface resistivity and presence of discoloration were measured using the methods presented below, and a servo tracking test was performed. The results are shown in Table 1.

[0117]

*Reproduction Output*

Signals having a recording wavelength of 0.6  $\mu\text{m}$  were recorded in using a head tester method. The reproduction output was measured and expressed relatively taking Comparative Example 1 as a standard (0 dB).

[0118]

*Light Transmittance*

Monochrome light with a wavelength used for reading servo signals was illuminated at the magnetic tape, and the ratio (percentage) of transmitted light to the incident light was determined and used as the light transmittance. The values shown in Fig. 1 are measurements before the formation of discoloration patterns recorded with servo signals on the pigment-comprising layer.

[0119]

*Coefficient of Friction*

Using a TBT-300D tape tester by Yokohama System Research Institute, each magnetic tape was run at a tape speed of 3.36 cm/s with the surface of the magnetic layer thereof in 180° contact with a cylinder having a 5-mm diameter. The winding and unwinding tension levels were measured, and the coefficient of friction ( $\mu$ ) was determined with the following equation (iii):

[0120]

Equation 3

$$M = (1 / \pi) \ln (\text{unwinding tension}) / (\text{winding tension}) \quad (\text{iii})$$

[0121]

*Electrical Surface Resistivity*

With two electrodes having a radius of 10 mm, plated with 24 K gold, and finished to have a roughness of N4 (ISO 1302), the electrodes were horizontally placed in parallel on the pigment-comprising layer so that the center-to-center distance  $d$  would be 12.7 mm. A direct current voltage of  $100 \pm 10$  V was applied to the electrodes while imposing a force of 0.25 N to both ends of the magnetic tape. The current between the electrodes was measured. The electrical surface resistivity was obtained from this value.

[0122]

*Presence of Discoloration in Discoloration Pattern Portion*

Laser light was illuminated at the pigment-comprising layer, the discolored portions (those stripped of color) were observed with an optical microscope, and the presence of a discoloration pattern was checked for.

[0123]

*Servo Tracking Test*

Signals were recorded on the magnetic layer while servo tracking was performed with a push-pull method using transmitted light on the magnetic tapes for evaluation obtained in the working examples and comparative examples, and the presence of control was checked for. The light used in the detection of the servo signals was of a wavelength identical to the light used in the measurement of transmittance of the magnetic tape shown in Table 1, and detection was carried out by converting the difference in transmission of that light between the discolored portion and the non-discolored portion of the pigment-comprising layer into electrical signals.

And in conjunction with this evaluation, the reproduction output of the recorded signals and the envelope characteristics were measured with a head tester. Reproduction output values use the value of Working Example 1 as the standard. Envelope characteristics were evaluated based on the following:

Circle: A constant output level and uniform envelope shape were attained across an entire track.

Triangle: There was a distorted envelope shape with a low output portion in the first or second half of a track.

[0124]

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[0125]

As is apparent from the results in Table 1, it is seen that the magnetic tapes of the working examples (products according to the invention) have a high reproduction output and enable reliable servo tracking. Reliable servo tracking such as that shown in Table 1 was performed even after 600 data tracks were recorded on the magnetic tapes of the working examples. In addition, both the dynamic coefficient of friction and the electrical surface resistivity values of the magnetic tapes of the working examples were low, and the pigment-comprising layer was deemed to have demonstrated the functionality traditionally associated with a backcoating layer. Although the arithmetic mean roughness and 10 point mean roughness values of the magnetic tapes of the working examples are not shown in the table, they were on par with those values of backcoating layers in standard magnetic tape.

[0126]

*Working Example II-1*

The following components (except the hardener) were individually kneaded in a kneader, dispersed in a stirrer, further finely dispersed in a sand mill, and filtered through a 1- $\mu$ m filter, and then the hardener was added to prepare a pigment-comprising coating composition, a magnetic coating composition, and an intermediate layer coating composition having the formulations described below.

[0127]

*Formulation of Pigment-Comprising Coating Composition*

Indium-doped tin oxide (ITO)	100 parts
(mean particle diameter: 35 nm)	
Silicone particles (mean particle diameter: 0.5 $\mu$ m)	3 parts
[Tospearl 105 (product name) by Toshiba Silicone]	
Phosphate ester (lubricant)	3 parts
(Phosphanol RE610 (product name) by Toho Chemical)	
3,3'-dipropylthiadicarbocyanine iodide (pigment)	0.2 parts
Polyurethane resin (binder)	28 parts
(number average molecular weight: 25,000; sulfoxyl group content: $1.2 \times 10^{-4}$ M/g; glass transition point: 45°C)	
Stearic acid (lubricant)	0.5 parts
Polyisocyanate (hardener)	4 parts

(Coronate L (product name) by Nippon Polyurethane Industry Co., Ltd.); solid content:  
75%

Methyl ethyl ketone (solvent)	120 parts
Toluene (solvent)	80 parts
Cyclohexanone (toluene)	40 parts

[0128]

*Formulation of Magnetic Coating Composition*

Acicular ferromagnetic powder containing primarily iron (Fe:Co:Al:Y:Ba ratio: 83:10:4:2:1 (by weight)) (major axis length: 0.09 $\mu\text{m}$ ; axis ratio: 1; coercive force: 145 kA/m (1822 Oe); saturation magnetization: 145 $\text{Am}^2/\text{kg}$ ; specific surface area: 56 $\text{m}^2/\text{g}$ ; X-ray particle diameter: 0.013 $\mu\text{m}$ )	100 parts
Alumina (abrasive; mean particle diameter: 0.15 $\mu\text{m}$ )	9 parts
Carbon black (mean primary particle diameter: 0.05 $\mu\text{m}$ )	0.3 parts
[Poly]vinyl chloride copolymer (binder) (mean degree of polymerization: 280; epoxy group content: 1.2% by weight; sulfoxyl group content: $8 \times 10^{-5}$ equiv./g)	6 parts
Polyurethane resin (binder) (number average molecular weight: 25,000; sulfoxyl group content: $1.2 \times 10^{-4}$ equiv./g; glass transition point: 45°C)	7 parts
Stearic acid (lubricant)	1 part
2-ethylhexyl oleate (lubricant)	2 parts
Polyisocyanate (hardener)	4 parts
(Coronate L (product name) by Nippon Polyurethane Industry Co., Ltd.)	
Methyl ethyl ketone	120 parts
Toluene	80 parts
Cyclohexanone	40 parts

[0129]

*Formulation of Intermediate Layer Coating Composition*

Acicular $\alpha$ -Fe <sub>2</sub> O <sub>3</sub>	100 parts
(mean particle diameter (major axis length): 0.12 $\mu$ m, axis ratio: 10; specific surface area: 48 m <sup>2</sup> /g)	
Alumina (abrasive; primary particle diameter: 0.15 $\mu$ m)	3 parts
Vinyl chloride copolymer (binder)	12 parts
(average degree of polymerization: 280; epoxy group content: 1.2 wt %; sulfoxyl group content: $8 \times 10^{-5}$ equiv./g)	
Polyurethane resin (binder)	8 parts
(number average molecular weight: 25,000; sulfoxyl group content: $1.2 \times 10^{-4}$ equiv./g; glass transition point: 45°C)	
Stearic acid (lubricant)	1 part
2-ethylhexyl oleate (lubricant)	4 parts
Polyisocyanate (hardener)	4 parts
(Coronate L (product name) produced by Nippon Polyurethane Industry Co., Ltd.)	
Methyl ethyl ketone	90 parts
Toluene	60 parts
Cyclohexanone	30 parts

[0130]

Thin metal layers comprising Au with a thickness of 0.05  $\mu$ m were formed using vacuum film formation on both sides of a 4.5- $\mu$ m thick polyethylene naphthalate film and used as the base. On one of the thin metal films was applied an intermediate coating composition and magnetic coating composition using multi-layer simultaneous formation and a die coater so that the dry thicknesses of the intermediate layer and magnetic layer were 1.5  $\mu$ m and 0.2  $\mu$ m, respectively. Next, the layers were magnetically oriented with a 400 kA/m solenoid while they were still wet. The tape was dried in a drying oven with 10 m/minute, 80°C heated air blown at the formed layers to dry them. After drying, the layers were calendared to form the intermediate and magnetic layers. Subsequently, the pigment-comprising composition was applied to the thin metal layer on the other side and dried at 90°C to obtain a pigment-comprising layer 1.0  $\mu$ m thick. Slits were inserted at a 12.7-mm width on the magnetic tape to obtain the magnetic tape with the construction shown in Fig. 7. The coercive force of the magnetic layer of the magnetic tape thus obtained was 151 kA/m (1898 Oe), saturation magnetic flux density was 0.36 T, angle ratio was 0.90, the arithmetic mean roughness Ra was 4.6 nm, and the 10-point mean roughness Rz was 55 nm.

[0131]

Next, as shown in Fig. 2, a plurality of discoloration patterns recorded with servo signals was formed on the pigment-comprising layer by shining a laser beam at the pigment-comprising layer of the resulting magnetic tape. The formation conditions of the discoloration patterns were as follows: the laser beam wavelength was 1020 nm, the output was 50 mW and the beam diameter was 2  $\mu$ m. The discoloration patterns thus formed were linear, parallel to the lengthwise direction of the magnetic tape, and continuous, and they were formed with equal spacing across the widthwise direction of the magnetic tape.

[0132]

*Working Example II-2*

The magnetic tape was obtained similarly to Working Example II-1, and the discoloration patterns were formed similarly to Working Example II-1 on the pigment-comprising layer of the magnetic tape except that the silicone particles added to the pigment-comprising coating composition used in Working Example II-1 were not added.

[0133]

*Working Example II-3*

The magnetic tape was obtained similarly to Working Example II-1, and the discoloration patterns were formed similarly to Working Example II-1 on the pigment-comprising layer of the magnetic tape except that crystal violet was used in place of the pigment in the pigment-comprising coating composition used in Working Example II-1.

[0134]

*Working Example II-4*

The magnetic tape was obtained similarly to Working Example II-1, and the discoloration patterns were formed similarly to Working Example II-1 on the pigment-comprising layer of the magnetic tape except that thionine was used in place of the pigment in the pigment-comprising coating composition used in Working Example II-1.

[0135]

*Working Example II-5*

The magnetic tape was obtained similarly to Working Example II-1, and the discoloration patterns were formed similarly to Working Example I-II on the pigment-comprising layer of the magnetic tape except that the amount of ITO added to the pigment-comprising coating composition used in Working Example II-1 was set at 80 parts, and 20 parts of TiO<sub>2</sub> with a mean particle diameter of 40 nm was added.



[0136]

*Working Example II-6*

The magnetic tape was obtained similarly to Working Example II-1, and the discoloration patterns were formed similarly to Working Example II-1 on the pigment-comprising layer of the magnetic tape except that the amount of silicone particles added to the pigment-comprising coating composition used in Working Example II-1 was set at 6 parts.

[0137]

*Comparative Example II-1*

The magnetic tape was obtained similarly to Working Example II-1 except that the pigment added to the pigment-comprising coating composition used in Working Example II-1 was not added.

[0138]

*Comparative Example II-2*

The magnetic tape was obtained similarly to Working Example II-1 except that a backcoating composition prepared from the following components was used in place of the pigment-comprising coating composition used in Working Example II-1.

Carbon black	40 parts
(Electrostatic preventing agent, mean primary particle diameter: 0.018 $\mu\text{m}$ )	
Nippouran 2301 (binder)	50 parts
(product name; Nippon Polyurethane Industry Co., Ltd. (solid content: 40%))	
Polyisocyanate (hardener)	4 parts
(Coronate L (product name) produced by Nippon Polyurethane Industry Co., Ltd.; solid content: 75%)	
Nitrocellulose	20 parts
Stearic acid	1 part
Methyl ethyl ketone	140 parts
Toluene	140 parts
Cyclohexanone	140 parts

[0139]

To evaluate the performance of the magnetic tapes obtained in the working and comparative examples, the reproduction output of the magnetic tape, the kinetic coefficient of friction of the pigment-comprising layer, and electrical surface resistivity and presence of discoloration were measured using the methods presented below, and a servo tracking test was performed. The results are shown in Table 2.

[0140]

*Light Reflectivity*

Monochrome light with a wavelength used for reading servo signals was illuminated at the pigment-comprising layer side of the magnetic tape, and the ratio (percentage) of reflected light to the incident light was determined and used as the light reflectivity. The values shown in Fig. 2 are measurements before the formation of discoloration patterns recorded with servo signals on the pigment-comprising layer.

[0141]

[Table 2]

[See original table for all numbers.]

		Magnetic tape			Pigment-comprising layer			Servo tracking test		
		Head tester reprod. output (dB)	Light used in servo sig. detec.		Dynamic coefficient of friction	Electrical surface resistivity ( $\Omega$ /[missing unit])	Presence of discoloration	Control	Reproduction output (dB)	Envelope
			Wavelength (nm)	Light transmittance (%)						
Working examples							Yes	Possible	o (standard)	
							Yes	Possible		
							Yes	Possible		
							Yes	Possible		
							Yes	Possible		
							Yes	Possible		
Comparative examples		o (standard)					No	Not possible		
							No	Not possible		

[0142]

As is apparent from the results in Table 2, it is seen that the magnetic tapes of Working Examples II-1 to II-6 (products according to the invention) have a high reproduction output and enable reliable servo tracking, as was the case with Working Examples I-1 to I-8. Reliable servo tracking such as that shown in Table 2 was performed even after 600 data tracks were recorded on the magnetic tapes of Working Examples II-1 to II-6. In addition, both the dynamic coefficient of friction and the electrical surface resistivity values of the magnetic tapes of Working Examples II-1 to II-6 were low, and the pigment-comprising layer was deemed to have demonstrated the functionality traditionally associated with a backcoating layer. Although the arithmetic mean roughness and 10 point mean roughness values of the magnetic tapes of Working Examples II-1 to II-6 are not shown in the table, they were on par with those values of backcoating layers in standard magnetic tape.

[0143]

***Effects of the Invention***

As has been described in detail, the invention provides magnetic tape that is capable of servo tracking without reducing the area of the data area.

The invention provides magnetic tape that is capable of servo tracking without losing the original functionality of the backcoating layer.

The invention provides magnetic tape with an improved track density.

The invention provides magnetic tape having a high recording capacity.

**Brief Description of the Drawings**

[Fig. 1]

A summary view showing the composition of the first embodiment of the magnetic tape of the invention.

[Fig. 2]

A schematic view illustrating a method for illuminating a light beam on the backcoating layer to form a discoloration pattern

[Fig. 3]

An expanded plan view of the essential parts of the backcoating layer following light-beam illumination.

[Fig. 4]

A schematic view illustrating the push-pull method of servo tracking.

[Fig. 5]

A schematic view (corresponding to Fig. 3) illustrating another embodiment of the discoloration pattern.

[Fig. 6]

A summary view showing the composition of the second embodiment of the magnetic tape of the invention.

[Fig. 7]

A summary view showing the composition of the third embodiment of the magnetic tape of the invention.

[Fig. 8]

A schematic view illustrating servo tracking in the third embodiment.

[Fig. 9]

A summary view showing the composition of the fourth embodiment of the magnetic tape of the invention.

[Fig 10]

A summary view (corresponding to Fig. 1) showing the composition of another embodiment of the magnetic tape of the invention.

[Fig 11]

A summary view (corresponding to Fig. 6) showing the composition of another embodiment of the magnetic tape of the invention.

[Fig 12]

A summary view (corresponding to Fig. 7) showing the composition of another embodiment of the magnetic tape of the invention.

[Fig 13]

A summary view (corresponding to Fig. 9) showing the composition of another embodiment of the magnetic tape of the invention.

#### ***Reference Symbols***

- 1: magnetic tape
- 2: base
- 3: intermediate layer
- 4: magnetic layer
- 5: pigment-comprising layer
- 6: backcoating layer

7: thin metal layer  
8: second thin metal layer  
10: discoloration pattern

Document name: Drawings

Fig. 1

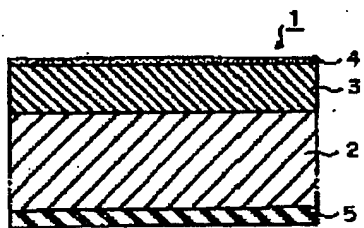
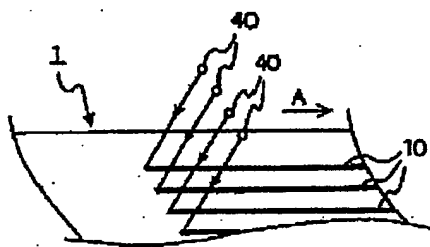


Fig. 2



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Fig. 3

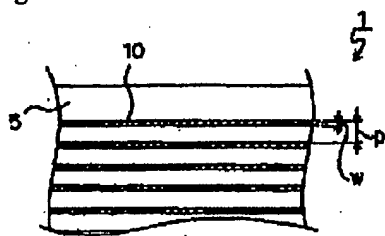




Fig. 4

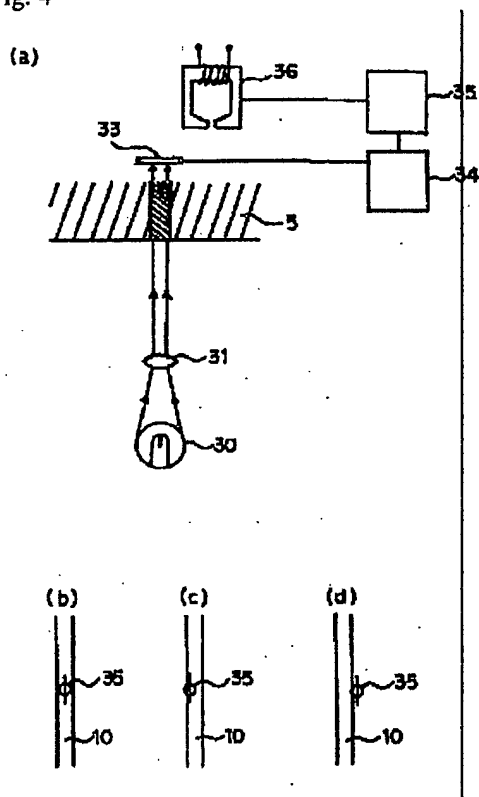


Fig. 5

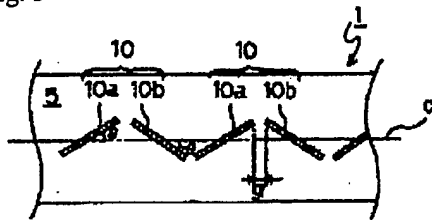


Fig. 6

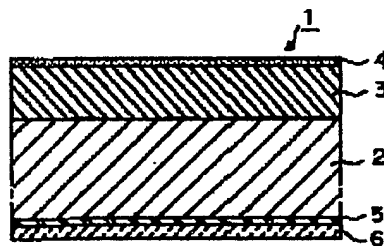


Fig. 7

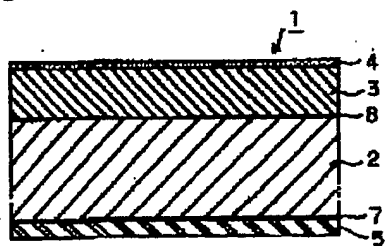


Fig. 8

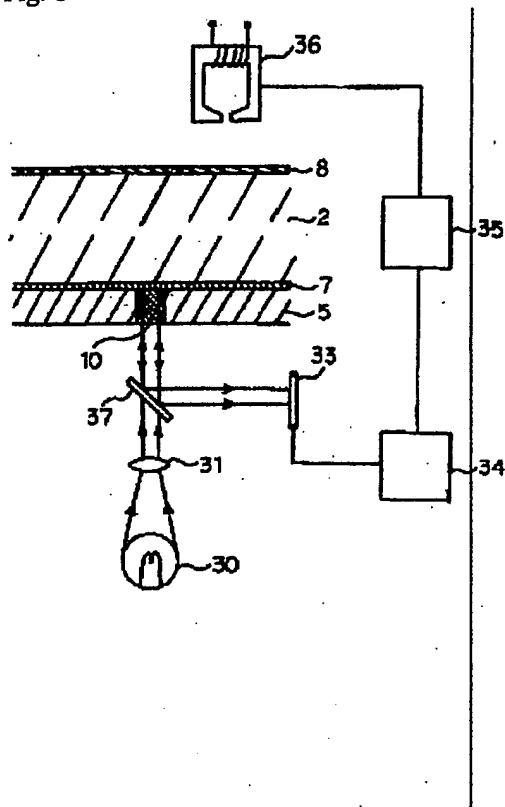


Fig. 9

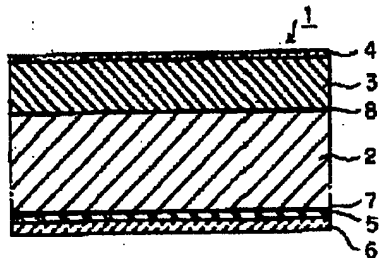
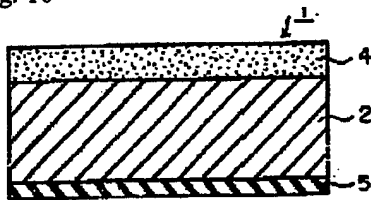


Fig. 10



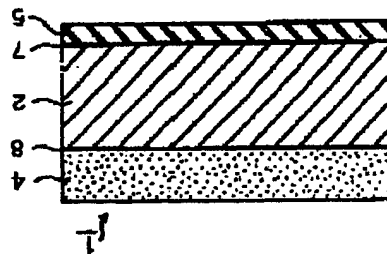


Fig. 12

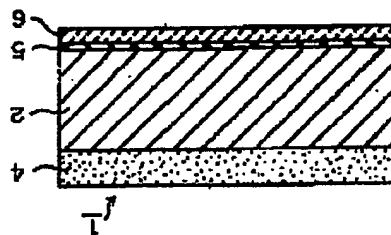
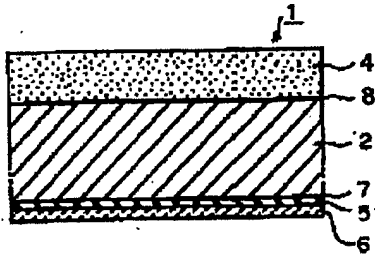


Fig. 11

Fig. 13



Document name: Abstract

**Abstract**

**Problem:** To offer magnetic tape capable of servo tracking without reducing the area of the data area.

**Means for solving the problem:** Magnetic tape characterized in that a layer comprising a pigment is formed on a surface opposite that on which a magnetic layer is provided on a base to make the layer a layer capable of optically recording servo signals for tracking.

**Selected drawing:** Fig. 1

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Document corrected: Patent application

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[Following page blank in original.]

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1. Correction of item present at time of application
2. Newly added item
3. Item appended to Amendment Form dated as follows:

If 3, Amendment Form dated \_\_\_\_\_.

Drawing to be published together with abstract. Drawing no. \_\_\_\_\_

Note: Input nothing if only the selected drawing is to be corrected.

Patent application no. H09-337733 (11/21/97)

Page: 1/1

Document name: Abstract

**Abstract**

**Problem:** To offer magnetic tape capable of servo tracking without reducing the area of the data area.

**Means for solving the problem:** ~~Magnetic tape characterized in that a layer comprising a pigment-comprising layer 5 is formed on a surface opposite that on which a magnetic layer 4 is provided on a base 2 to make the pigment-comprising layer 5 a layer capable of optically recording servo signals for tracking.~~

**Selected drawing:** Fig. 1



A pigment-comprising layer 5 particularly comprises a binder from the standpoint of using the pigment-comprising layer 5 also as a backcoating layer and improving the running characteristics and durability of the magnetic tape 10 [sic].

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